Case 1910
GT/ert

ELECTROCHEMICAL SENSOR WITH INCREASED REPRODUCIBILITY

The present invention concerns an electrochemical sensor in the shape of a tongue intended to measure, using a reactant which is deposited beforehand on its working electrode, the concentration of a constituent in a sample solution or liquid or natural or biological origin in a reproducible manner from one sensor to another sensor.

The invention concerns more particularly sensors of this type which are used for the medical follow-up of a patient requiring frequent measuring of a constituent in a biological body fluid so as to adapt a treatment as a function of a reference value, such as the blood glucose level for a person suffering from diabetes.

During the last ten years, the generally disposable electrochemical sensors, intended for biological measurements, have experienced considerable development aimed at improving qualities, such as sensitivity, reliability, speed of response or ease of use by a user. Generally speaking, these sensors are formed by an insulating support of small dimensions, supporting at least two conducting strips electrically separated and able to be connected at one end to an electronic measuring device, said conducting strips being covered with a film into which two windows are cut exposing portions of strip respectively forming the reference electrode and the working electrode on which there is immobilised a determined quantity of specific reactant of the constituent whose concentration one wishes to determine. After having deposited the sample to be analysed on the measuring zone, for example a drop of blood, the measurement is effected indirectly by exploiting an electric signal generated by the interaction between said specific reactant and said constituent.

This exploitation of the electric signal consists generally in conductometric, voltainmetric, amperometric, coulometric or polarographic measurements allowing an electronic measuring device to interpret said signal and to display the concentration of the constituent in a determined mode (mg/dl, mmol/l) directly on a screen. In order for the displayed value to always be the same for a determined concentration, the electric signal supplied by the sensor must not vary as a function of the sensor used, i.e. these sensors must be able to be manufactured at a low cost in series to be disposable via a method which nonetheless guarantees a high degree of reproducibility. The parameters which can be acted on are in particular the dosage precision of the various compounds involved in the composition of the specific reactant, the precision of the quantity of reactant deposited on the working electrode, and the precision of the useful surface of the electrodes, in particular the surface of the working electrode which is actually covered by the specific reactant. It is relatively easy to obtain a high level of

precision for the composition of the reactant and for the quantity deposited on the working electrode. Following the teaching of European Patent No. 0 787 984, it is also possible to have a high level of precision as regards the useful surface of the electrodes by having conducting strips which pass through the windows without leaving any portion of the substrate apparent. However, the Applicant has noticed that it is relatively difficult to have a perfect reproducible covering of the useful surface of the working electrode by the specific reactant when it is applied by pipetting in windows of the current shapes, namely rectangular windows or windows in the shape of a half-moon, i.e. in both cases windows having contours with sharp angles.

The material into which the windows are cut is generally a hydrophobic material, such as polyethyleneterephtalate (PET). This hydrophobic phenomenon is in competition with the capillary properties of the specific reactant, so that when the desired quantity of specific reactant is deposited at the centre of the window by pipetting, it is not spread uniformly over the entire useful surface of the working electrode. In particular, very irregular covering is noted at the sharp angles.

In order to overcome this, it is possible to effect the deposition of the specific reactant via pipetting by starting by following the contour of the window as closely as possible the contour and/or by giving the pipette a certain inclination. It can easily be seen that such a method is not applicable to series manufacturing in which the sensors are manufactured in batches on substrates in a plate or strip shape prior to being cut to be packaged individually.

In order to make the contour of the window hydrophilic, pre-treatment with an alcohol has also been tried. Indeed, better wettability of the window is obtained, to the point that the specific reactant also spreads over the PET covering sheet. It is difficult, even impossible, to perform this hydrophilic treatment only in the vicinity of the vertical edges of the covering sheet.

The object of the invention is thus to overcome the drawbacks of this prior art by providing an electrochemical sensor wherein the useful surface of the working electrode is covered in a uniform and reproducible manner by a specific reactant of a constituent present in a solution or a liquid of natural or biological origin, as a result of a shape which is oblong in the direction of the tongue and given at least to the window delimiting the useful surface of the working electrode including said specific reactant.

Other features and advantages of the invention will appear more clearly upon reading the following detailed description, concerning by way of illustrative and non limiting example an electrochemical sensor for determining a level of glucose in the blood, with reference to the annexed drawings; in which:

- Figure 1 shows in perspective a sensor according to the invention;

- Figure 2 shows an enlarged top view of the measuring zone of the sensor of Figure 1;

Figures 1 and 2 show an electrochemical sensor for measuring the level of glucose level in the blood, i.e. a sensor whose measuring electrode is coated with a specific reactant 10 the composition of which will be explained hereinbelow. This sensor has the shape of a thin tongue of small dimensions of a total thickness comprised between 0.40 and 0.80 mm, preferably approximately 0.60 mm, a width comprised between 6 and 12 mm preferably approximately 8 mm and a length of the order of 40 mm.

The sensor includes a thin insulating substrate 1, for example obtained from a sheet or a strip of polyethyleneterephtalate (PET). The substrate carries two conducting strips 4 and 5 which are electrically insulated by a narrow strip 3 of substrate 1. The nature of conducting strips 4, 5 and the way in which they are applied onto substrate 1 are well known to those skilled in the art. The preferred method within the scope of the present invention consists in hot rolling two insulating films having a metallised surface for conducting strip 4 which will form working electrode 9a and for conducting strip 5 which will form reference electrode 9b. These two metallised films can be identical or conversely have different metal coatings. For example, the well known pair Pt or Pd - Ag/AgCl can be used. The assembly is covered with an insulating covering 2 into which are cut two zones 8, 9 allowing portions of conducting strips 4, 5 to appear. A first zone 8, located at one end of the sensor, allows said conducting strips 4, 5 to be connected to the electronic measuring device. A second zone 9 constitutes the measuring zone on which a drop of blood to be analysed will be deposited. It includes two windows located respectively above portions of strips 4, 5, a first window 9a delimiting the working electrode and a second window 9b delimiting the reference electrode, without allowing any position of substrate 1 appear. These two windows 9a, 9b are separated by a strip 11 of insulating covering 2.

The two windows 9a, 9b are characterised in that they have an oblong shape in the direction of the tongue. In the preferred embodiment shown in Figure 2 it can be seen that windows 9a, 9b have a " coffee bean " configuration, i.e. inscribed in a circle so that a drop of blood deposited in this zone covers them perfectly and the ionic junction is facilitated by the closeness of the opposite edges. This configuration thus allows a determined quantity of specific reactant 10 to be deposited by pipetting substantially in the middle of measuring window 9a and perfect covering of the entire useful surface of the working electrode to be obtained without spreading or overflowing beyond said window. In the example chosen concerning the determination of a glucose level, the specific reactant includes in particular glucose oxide (GOD) and a

mediator allowing the electrons to be transferred, for example one of the mediators described in US Patent No. 5,378,628, namely mono, bis or tris 2-2' ruthenium, osmium or vanadium bipyridines complexes in which at least one of the bipyridine ligands is substituted by at least an electron donor group.

When the windows are made by stamping, which forms the preferred embodiment, the formation of " angel hair " has however often been observed in the sharp angles, i.e. very fine filaments which can also be responsible for the poor distribution of specific reactant 10 at this location. With the curvilinear contour according to the invention, this drawback is completely eliminated.

The preceding description was made with reference to an electrochemical sensor for determining a glucose level, but those skilled in the art may, without departing from the scope of the invention, make the necessary adjustments for any other type of electrochemical sensor for determining or measuring other chemical or biological parameters.